INDIAN TEA ASSOCIATION.

SCIENTIFIC DEPARTMENT.

TOCKLAI EXPERIMENTAL STATION.

ANNUAL REPORT 1951.

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1. CHIEF SCIENTIFIC OFFICER'S REPORT.

(1) Staff.

The Senior Staff at the beginning of 1951 was as given in the Annual Report, 1950.

Dr. E. A. H. Roberts was on leave in 1951 and in October took up the post of Chemist in charge of research on Tea Chemistry, under the Indian Tea Association, London. His post of Chief Biochemist at Tocklai was taken by Mr. D. J. Wood.

Mr. E. Hainsworth resigned his post of Plant Pathologist in May 1951 and it has not been found possible so far, to obtain a suitable replacement. Mr. J. W. Crichton (Advisory Officer, Dooars) unfortunately had to resign for family reasons and left the Station in October. Mr. A. D. Swan joined the Station as Advisory Officer, Cachar, in November and after training at Tocklai will take up his duties in Cachar at the end of 1952. Suitable accommodation has already been found for him at Urrunabund Tea Estate.

Mr. I. McTear who was appointed Resident Engineer, arrived at Tocklai in December.

Mr. J. M. Trinick was appointed Tea Taster in place of Mr. R. J. Gilchrist who resigned in 1950. Mr. Trinick took up his duties in June, and early in December proceeded to London for discussions with brokers and Mr. Gilchrist regarding the tasting and valuation of Experimental teas.

The Staff at present is as follows :—

C. J. Harrison	...	Chief Scientific Officer,
W. Wight	...	Plant Physiologist,
D. J. Wood	...	Chief Biochemist,
N. G. Gokhale	...	Physical Chemist,
S. K. Dutta	...	Agronomist,
G. M. Das	...	Entomologist,
R. I. Macalpine	...	Advisory Officer, Darjeeling,
P. M. Glover	...	" " Assam Valley & North Bank.
A. D. Swan	...	Advisory Officer, Cachar,
J. M. Trinick	...	Tea Taster,
I. McTear	...	Resident Engineer,
J. Watson-Morton	...	Executive Officer.

(2) Buildings.

The extension to the Chemical Laboratory was completed and now houses the Soil Chemistry and Physics Branch, (including the Meteorological Section). No. 3 Bungalow was rebuilt. A start was made with the building of the Resident Engineer's Bungalow.

(3) Lecture Courses.

A series of 3 weekly general lecture courses was held in February-March, and was attended by a total of 68 Managers and Assistants.

(4) Conference.

The Annual Tocklai Conference was held on 3rd, 4th and 5th December. Sir P. J. Griffiths and Mr. A. N. Stuart from the London Committee were present during the latter part of the Conference.

(5) Scientific Department Sub-Committee.

Four meetings of this Committee were held during the year, two of which were held at Tocklai, on 12th May and 6th December.

(6) Visitors.

The Station had the usual large number of visitors during the year, including H E. Governor of Assam, the Assistant High Commissioner for the U. K., and U. S. Consul General, Calcutta, and several members of the London and Calcutta Indian Tea Association Committees.

(7) Publications.

Six Serials of the Tea Encyclopaedia were published during the year. The complete list now comprised 88 Serials up to the end of 1951.

Mr. P. M. Glover, Advisory Officer, Assam Valley & North Bank, was appointed representative of the Scientific Department on the Cachar Plantation Enquiry Committee set up by Govt. of India to enquire into the causes of uneconomic working of a number of gardens in that District. Mr. Glover's report on tea cultivation in Cachar, with recommendations as to methods of improvement, was published in February.

C. J. Harrison.
Chief Scientific Officer.

AGROBOTANICAL BRANCH.

PLANT PHYSIOLOGY AND PROPAGATION.

(1) Phloem Index.

(Para 1 of 1950). It has been established that the phloem index is a function of phenotype. Hybrid phenotypes drawn from a number of random, freely interbreeding seed sources, can be grouped according to certain standard taxonomic criteria ; the group intervals may be regarded as of unit value, each successive group in the taxonomic array (northocline) thus increasing its (ordinal) value in arithmetic progression ; when this is done, the magnitude of the phloem index may be expressed as an exponental function of the taxonomic index (if this be treated as a numerical value), of the form —

$$y = Ae^{-kx^2}$$

A particular *genetical balance* in the middle of the array results in a maximum phloem index and the value of the phloem index diminishes in proportion to the deviation from this state of balance. A similar conclusion applies to the gross potassium content of the leaf when determined by standard analytical methods.

(2) Minor nutrient elements.

(Para 3 of 1950). Correlations have been obtained between dosage, as top dressing, of certain minor nutrient elements and the growth of young tea plants. The response to such elements appear to be confined to small and localised patches of soil, so that the gross overall response of an appreciable area of tea plants is not of significance. The use of these elements is not likely to be of general practical utility, but they may become of importance for vegetative propagation and for replanting old tea areas. The elements investigated were boron, sodium, magnesium, sulphur, copper, calcium, zinc, and manganese.

(3) Organic nitrogen.

The form in which nitrogen is presented to the tea plant influences its nutrient value. Whilst the following observations are based upon data which are not sufficiently extensive to imply finally, the indications are important. In respect of one clone, the optimum dose of nitrogen as urea resulted in a higher yield than the optimum dose of nitrogen as sulphate of ammonia. When the nitrogen dose was raised to levels which were comparatively depressing under 50% light intensity (under bamboo screens), then urea was found to be less depressing than sulphate of ammonia. In respect of heterogeneous populations of plants raised from seed, the organic substance oil cake, on the comparative basis of total nitrogen (300 lbs. N) can result in a higher yield in full sun than sulphate of ammonia (300 lbs. N). A dosage of nitrogen as oil cake which was depressing in full sun (600 lbs. N) was not depressing under 50% light intensity. *Organic and inorganic nitrogen interact with light intensity in respect of the growth of the tea plant.* It had previously been concluded that cow dung is not superior to a balanced NPK mixture both being under a shade tree canopy. It is suggested that the presence of particular organic forms of nitrogen are of importance in the metabolism of the tea plant and its associated mycorrhizal fungus. The possibility of shade *per-se* being of

continued long term efficiency (para 4 below) may depend upon the continued presence of particular sources of nitrogen in the soil which are required for the metabolism of the mycorrhizae. It is important to note that the formation of mycorrhizae in conifers has been found to be conditioned by light intensity (Björkman 1942. Biol. Absts. 20 : 7878. 1946).

(4) Shade Canopy.

In respect of the first season of treatment, the crop yield under bamboo screens which reduced the light intensity to that obtaining under an *Albizzia stipulata* canopy (50%) resulted in a yield in excess of that obtaining under the shade tree canopy, but not significantly so ; the yield difference was not significant. In either case the yield under shade was significantly greater than that in full sun and of the order of a 50% increase. Irrespective of any future alteration of comparisons between the treatments it is proved that a *tree canopy provides a primary physiological requirement of an optimum light intensity* ; also, some natural sources of nitrogen in the soil are probably exploited by the plant with geater efficiency under a reduced light intensity. The greater part of the nitrogen in soil is present in organic from ; and it is suggested, particularly for tropical and semi-tropical conditions, that the nitrogen sources which are utilised under shade consist of comparatively non-decomposed organic matter. The mycorrhizae would be of importance in utilising these sources of nitrogen. The absolute yield under bamboo covers was 16 mds. of tea per acre and it is important to note that the amount of nitrogen so removed, might not exceed the total of that possibly fixed annually by soil azotobactor and added by rain ; so that there is a theoretical possibility of shade *per-se* being of continued efficiency provided that annual prunings are returned to the soil.

(5) **Sulphate of ammonia.**

A specific magnitude or value may be assigned to a given phenotype (*vide* para 1 above); this value has been designated as the *agrotype index*. Though these values are *ordinal* in origin they possess attributes of numerical importance. It has been established that agrotype determines growth response to sulphate of ammonia. Ten years summated yield increases over check (y) due to manuring with sulphate of ammonia, are an exponental function of agrotype index —

$$y = Ae^{-kx^2}$$

These observations include the full range of agrotypes now used for replanting in the plains of Asaam, but exclude many *positive* agrotype (those with pronounced *sinensis* attributes) characteristic of older plantations. There is a modal value of yield response to sulphate of amonia, associated with a median agrotype. These results are for manuring in full sun. If a shade tree canopy be used in lieu of sulphate of ammonia, then similar results are obtained. With the particular spacing of the leguminous shade tree *Albizzia stipulata* of 40 ft. by 40 ft., and the particular nitrogen dosage of 80 lbs. as sulphate of ammonia, the summated data for ten years show yield response to either treatment to be an exponental function of agrotype index : for any agrotype

index within the limits, there is no significant difference between the magnitude of response to either treatment; thus *the shade tree canopy entirely replaces doses of nitrogen up to 80 lbs. per acre;* and the magnitude of yield due to these factors is genetically determined. But the yield under the particular shade canopy, equal to that from 80 lbs. of nitrogen, can be exceeded by the use of higher doses of nitrogen in the absence of a canopy, at least in respect of particular agrotypes. This is dependent upon the rate of yield increase of an agrotype in respect of nitrogen dosage, this rate (though truly exponential) being approximately linear within the limits of nitrogen dosage considered in our experiments. The median agrotypes give the greatest rate of yield increase to increasing doses of nitrogen, and the rate of response of agrotype to nitrogen in full sun diminishes in proportion to their deviation (positive or negative) from the median agrotype index. The median agrotypes, therefore, are those in which higher doses of nitrogen (in full sun) are most likely to result in a yield in excess of that produced by the particular canopy. When 80 lbs. of nitrogen is used in conjunction with the given canopy, then the yield response measured as increase over the check (neither manure nor shade) is a *linear function* of agrotype index, the yield response diminishing as the agrotype index increases. At the median agrotype index the yield increase due to the conjoint factors is the same as to either separately; only those plants which deviate from a certain median range of agrotype index will give a response to nitrogen under the particular shade canopy, which is economically greater than that to be obtained from the particular shade density alone (this shade density producing the same yield as 80 lbs. of nitrogen). This suggests that the use of other shade densities, appropriate to other agrotypes beyond the ascertained median range, might extend this range to include still more agrotypes in respect of which shade could completely replace doses of nitrogen up to the particular level of 80 lbs. Practical applications will depend upon Garden Surveys of shade density and agrotype index, so that available sulphate of ammonia may be used in increasing amounts upon those sections which will give the best return. In the absence of such surveys, nitrogen is inevitably applied to sections of tea which will not respond. Sample surveys show that approximately 50% of the nitrogen which is used is applied to plants which are incapable of response, either on account of agrotype and/or shade density. An evaluation of agrotype by districts shows that the Assam Valley, the Dooars, and the Surma Valley differ materially in kind of tea plant. Within the limits of agrotype of known response, much of the tea in the Surma Valley is unable to respond to nitrogen under the particular shade canopy; and if such a shade canopy be present, then it is likely to replace doses of nitrogen up to 80 lbs. for a large proportion of the Surma Valley acreage of those agrotypes of ascertained response. This subject is treated in greater detail in the Proceedings of the Ninth Annual Conference 1951. Two factors become of importance in tea breeding — the ability of the plant to respond to nitrogen and to shade, these responses being inter-related and determinable from agrotype index (see also para 1 of 1950); and quality, this factor being determinable from hair (*vide* para 8 following, and para 4 of 1950).

(6) Root Growth

(Para 2 of 1950). The statistics of this work remained in abeyance.

AGRONOMICS AND BREEDING.

(7) Planting distance and yield

(ref. Bot. Branch Memorandum No. 67, 1948). The efficiency with which tea plants cover the ground is dependent upon the innate factor of spread or diameter of the bush. A planting efficiency of 100% is attained when the yield per acre of ground is equal to yield per acre of bush surface. If yield per acre of bush surface be designated as nett yield and yield per acre of ground be gross yield, then with inefficient (wide) spacing, bushes of high nett yield will permanently fail to produce their potential gross yield. No amount of cultural treatment will materially alter innate differences of spread. Efficient spacing, designed to produce maximum gross yield, depends upon the natural innate spread of the plant ; and the level of maximum yield with efficient spacing depends upon the nett yield of the plant. When bushes with a naturally wide spread are spaced sufficiently closely to restrict their potential spread, it appears unlikely that there will be any appreciable increase in nett yield. These observations are particularly relevant to the cultivation of clones, but they apply also to the average attributes of seedling populations ; and they will become of increasing importance with more refined and more uniform sources of seed ; because innate differences of growth habit between sources will become more pronounced than is the case at present. It would appear that the efficiency of hedge planting is depended upon the use of clones with a high nett yield, or upon the use of seed sources which provide a high percentage of such plants. No long term advantage is to be expected from the close spacing of plants with a innate wide spread, nor from the closer spacing of plants which show a comparatively high gross yield when this is measured on the basis of some common standard spacing. Theoretical considerations and the minimum requirements for practical convenience of plucking, indicate 3.5 × 3.5 ft. triangular spacing to be necessary for ordinary commercial seedlings to attain a comparatively efficient gross yield at five years age. Wider spacing will attain the same level of efficiency only at a greater age. It is for the practical man to decide whether the inconvenience of "mature" (say 20 years) 3.5 ft. spaced bushes is best overcome by occasional cutting of the side *dhals* (stems) at the time of pruning ; or alternatively, of satisfying convenience by an initial wider spacing and at the same time rigorously prohibiting the cutting of side *dhals* with the object of increasing spread, as is the custom at present. There appears to be a tendency for plants of high quality to be deficient in spread — the bush frame of such plants may be not well developed ; on the other hand, such plants may possess satisfactory or even unusually high nett yield.

(8) Quality.

(para 4 of 1950). Hair and quality are correlated when these co-variates are derived from different populations of plants. Further investigations show that the correlation within a population is not of constant magnitude in

respect of seasonal or time trend; quality is positively influenced both by amount of hair and by the amount of solar radiation to which the growing leaf has been subject prior to manufacture. Additional importance is given to this observation by the use of a shade canopy as an essential part of the system of tea cultivation. The innate amount of hair is determined by the phenotype or genetical status of the plant. The growth of the hair on a plant in respect of time trend, is correlated with the meterological factor of hours of sunshine and relative humidity; the factor of vapour tension being of lesser significance than that of relative humidity; and the magnitude and also the direction (sign) of these correlations is influenced by the phenotype. Preliminary investigations suggest that within certain limits, quality is positively associated with yield: a more detailed report must await the outcome of current investigations. No one of the factors separately enumerated in a tasters report, as strength, briskness or quality, separately gives a generally satisfactory estimate of the cash valuation which may be termed "average consumer appraisal"; but by giving suitable ordinal values to degrees of the several taster attributes, it is possible to obtain a composite numerical formula which gives satisfactory agreement with the tasters cash valuation. This formula is linked with amount of hair—which is intrinsically the same as *tip*—and hence also with meterological factors. Because of the inter-relations of several taster attributes with cash value it is possible to examine the internal consistency or coordination of a taster's reporting, with reference to a system which may be accepted as standard; and provided that he is assessing value against a standard kind of tea, uninfluenced by market trend (or provided that statistical allowance is made for market influence). This investigation is incomplete and will be continued during 1952. In collaboration with our taster (Mr. Trinick) increasing attention has been given to the distinct factor of flavour. It seems likely that flavour is to be determined for the purposes of breeding, by the presence of *fragrantly* aromatic flowers. Breeding amongst stock possessing such flowers has resulted in offspring possessing a flavour which would place their origin in the Darjeeling district. The verbiage "flavour" is a survival amongst tasters of an old usage of the term to connote "aroma"; but a specific kind of aroma is implied, and other aromas may be referred to as "taint"; for example, objectionable aromas of the goaty and capryllic class seem to be innate in certain plants. Because of the fundamentally composite nature of nearly all aromas; and because the synthesis or blending or a characteristic desirable aroma requires the presence of individual aromas which in themselves are objectionable (as civet), it therefore seems undesirable to exclude from the purview of the breeder plants which may possess such attributes. These considerations also raise the extreme improbability of a single clone being able to produce teas with the already accepted characteristic of certain Darjeeling flavours. Similar, but lesser degrees of improbability apply to the general acceptability of the teas produced from a single plains type of clone (*assamica*) as being characteristic of Assam teas in respect of tongue-taste (flavour being comparatively unimportant).

Breeding for the attributes of made tea has a satisfactory material basis which excludes the initial need for a taster ; but the services of a taster will become of importance in determining the scientific blending of associated plantations of the clones which are the independent product of garden selection.

No evidence has been found for a relation between phloem index and quality.

(9) Breeding.

This is the eleventh year of the Association's tea breeding programme, commended in 1940. On account of the Staff reduction and great pressure of work in the Agricultural Laboratory the requisite propagation and trials (which, in fact, constitute the act of breeding) have not been possible and breeding is now four years behind programme Two pairs of generative clones have been found (Nanda Devi scheme) each of which produces offspring the manufactured leaf of which possesses the attributes of Darjeeling tea when grown and manufactured in Jorhat. The offspring are of a type (*Cambodiensis — sinensis attributes*) known to grow satisfactorily in Darjeeling and are well above the average uniformity and vigor of this kind of plant. Further progress is visualised by cross matings with inbred *assamica* types (see below); meanwhile, plants of the existing generative clones will be given to the Darjeeling Advisory Officer for the production of F_1 seed in or near to the Darjeeling district.

One pair of generative clones has been found which produces offspring of the *assamica* type, suited to cultivation in the plains of Assam ; though not ascertained by trial, it seems likely that these offspring will respond well to shade without the use of nitrogenous manures. As the parental clones are very similar, the F_1 is inbred. The offspring are highly pubescent and the bulked leaf of the entire population possesses a most unusually high level of quality. Uniformity is good and nett yield is satisfactory but the plants lack both spread and robustness and are unsuited for large scale cultivation. Further inbreeding within this line (Landikotal scheme) is necessary to increase the quality factor (with further loss of vigor) with the object of producing an heterotic F_1 when a cross mating with another suitable inbred *assamica* line becomes possible.

The offspring of 15 matings have been found unsuitable and have been destroyed.

Ideally, an F_2 should be produced from inbred parents which have been demonstrated to possess a good degree of homozygosity. Partly on account of the time factor – seven years being required for one generation—the Association's breeding programme started on more empirical lines. Pairs of parents, deemed likely to produce uniform offspring (in respect of some attribute, not necessarily morphological) were chosen from the hybrid universe of commercial plants. As the tea plant is comparatively self-infertile, two clones will generally be necessary for the practical production of seed. Many of the F_1 have shown striking degrees of uniformity and are readily distinguishable one from the other ; these indicate the stocks amongst which inbreeding and selfing can most profitably

be pursued. Thus, the two methods of approach are naturally complementary ; and the point is established that experienced personnel can assess the value and breeding behaviour of a chance hybrid phenotype with an accuracy sufficient for breeding operations ; and the practical outcome of these operations depends largely upon the conduct and co-ordination of very extensive field operations at Borbhetta for which our present staff is inadequate.

(10) Vegetative Propagation

(para 3 of 1950). This work remains in abeyance, but is connected with that reported in para (2) above.

(11) Rim-blight, zig-zag and leaf roll

(para 5 and 6 of 1950). This work remains in abeyance.

(12) Seed

(para 7 of 1950). Considerable progress has been made in statistical treatment, but no report will be possible until 1953 after the Plant Physiologist returns from Home leave in the cold season of 1952.

(13) Plucking and Pruning.

(paras 8 and 9 of 1950). Many years work was reported in 1950 and no further research on these subjects is to be expected for some years.

W. Wight.
Plant Physiologist.

APPENDIX TO AGROBOTANICAL BRANCH
ANNUAL REPORT 1951.

Staff :

The Agronomist, S. K. Dutta, Esqr., B. Sc., proceeded to U. K. on Home and Study leave on 19th March, 1951 and returned to Tocklai on the 30th December, 1951.

Mr. P. Saidinga was given a temporary appointment as Field Assistant, Junior Grade with effect from the 13th February, 1951, which he resigned on the 30th June, 1951.

Messrs R. N. Barua and J. N. Bhuyan were given temporary appointments as Field Assistant, Junior Grade with effect from the 14th June, 1951 and 15th June, 1951 respectively.

Labour :

The average monthly attendance during the whole year was -

Tocklai	...	21.20
Borbhetta	...	279.94

Rice allowance was given to the labour during the year from Rs. 2/- to Rs. 5/6/- at a sliding scale.

Advisory :

93 letters were written by the Agronomist, 33 of which were of technical advice ; and the Plant Physiologist wrote 138 technical memoranda during the year.

Lectures :

The Agronomist and the Plant Physiologist delivered five and six lectures respectively in the Cold Weather Lecture Course held at Tocklai during the month of February, 1951.

Crop Yield : (Borbhetta).

The total crop yield of the year compared with that of 1950 were as follows :—

1950 — 3,97,567 lbs.
1951 — 2,59,589 lbs

Plucking was closed on 8th October, 1951.

2,41,882 lbs. of green leaf was sold to Chenijan Tea Estate during the year @ Rs 20/- per maund.

BIOCHEMICAL BRANCH.

STAFF.

Dr. Roberts proceeded on home leave in March, and later announced his resignation from Tocklai in order to undertake research into tea chemistry under the Indian Tea Association in London, an appointment which has been vacant since the resignation of Dr. Bradfield. Mr. wood has now assumed charge of the Biochemical Department.

Mr. Trinick, who joined Tocklai in June, has been attached for this season to the Biochemical Department. In December he proceeded to the U. K. for a short period of study leave.

Touring.

Mr. Wood carried out two tours of the Dooars and Terai, one in April/May and one in September, during which he studied general manufacturing conditions and practices, paying particular attention to the no-wither, tobacco cut system of manufacture. One garden in Darjeeling was included in the September tour. Individual gardens in the Jorhat, Golaghat and Dibrugarh districts were visited by Mr. Wood and Mr. Trinick in connection with manufacturing problems and experiments.

Advisory.

Memoranda and advisory letters on subjects connected with manufacture totalled 106. In addition Mr. Trinick issued a large number of reports on samples sent to him for tasting.

Publications.

Encyclopaedia Serials 83 (Factory Requirements for a 10,000 maund Crop), 84 (Green Leaf Sifting) and 28/1 (Firing of Tea) were issued during the year.

Tasting.

Mr. Trinick tasted and reported on 2,686 tea samples. Among those sent to Tocklai by gardens a large number were single bush samples from clonal selection schemes.

Fundamental Research.

Changes in pH during Manufacture.

An investigation of changes in pH during the various stages of manufacture has been begun. Measurements have been made with a glass electrode. No changes have been observed as a result of either withering or firing. During fermentation there is a progressive fall in pH. which seems likely to be due to the liberation of free gallic acid. The condensation of oxidised catechins does not appear to cause appreciable change of pH. Refluxing an infusion of fermented or partially fermented tea (which leads to greatly increased condensation) produces a slight fall in pH. However a much greater fall accompanies the refluxing of a green leaf infusion.

Soluble Enzyme.

It has been found possible to render the enzyme responsible for fermentation much more readily soluble by pre-treatment with n-butanol. In one experiment where enzyme, in the form of a dry acetone powder, was treated with butanol and reduced 80% of its activity could be extracted by phthalate buffer. Such a solution could form the starting material for attempts to purify the enzyme.

Theanine.

In the Annual Report for 1950, and in many of our past Quarterly Reports, we have referred to an important nitrogenous constituent of tea which we have termed 10 G. On chromatograms of various types of tea it is always present, usually as the most abundant component of the amino-acid complex. This substance has now been identified in Japan as L-glutamic acid gammaethylamide, a compound not previously known, and has been named theanine. Prior to the announcement of its identification, work on its chemical properties had been continued by us. We had shown that it was an amide of glutamic acid with properties quite distinct from those of glutamine, that it was not a peptide, that half its nitrogen was in the form of amide groups and that it had one free carboxyl group for every two nitrogen atoms. The fact that it is more abundant than either of the other two amides, glutamine and asparagine, and that its greatest concentration is found in the stem and in the innermost portion of the bud, suggest that it must play an important physiological role.

APPLIED RESEARCH AND MANUFACTURE.

Time of Plucking.

Many plants exhibit fairly marked diurnal changes in chemical composition. If changes of this nature occur in the tea plant they are likely to affect liquoring properties. In an attempt to link up liquor characters with chemical composition groups of bushes belonging to a single clone have been plucked at different times of the day, and samples of the manufactured teas sent to various Tasters. At the same time the enzyme activity ($Q0_2$) and the total oxygen uptake of the freshly plucked leaf have been measured. The plucking times were 6. 30 a. m., 10. 30 a. m. and 2. 30 p. m. ; manufacture was in Pizey rollers.

Colour is best developed in the 6.30 sample, and falls off progressively with later time of plucking. The overall opinion on strength is that it follows the same trend as colour ; the difference between the 6.30 and 10.30 samples however is very slight, while the 2.30 sample is considerably weaker than either. The order of preference for strength is not agreed upon by the various Tasters. Quality and briskness cannot be said to exhibit any trend, particularly as opinions in some cases differ considerably.

The $Q0_2$ and total oxygen uptake are highest in leaf plucked at 6.30 and lowest in leaf plucked at 2.30. A decrease in either $Q0_2$ or total uptake will give a tea with less colour and strength ; other liquor characters may not be affected. The tasting results can thus be explained as due to a diurnal fall in enzyme activity and total uptake ; there is no indication that other changes are involved. The total oxygen uptake is a measure of the amount of oxidisable polyphenol, which accordingly appears to decrease during the day. This however needs confirming by other methods. No fresh information has been gained as to the relationship between chemical composition and liquor characters.

Withering.

Various small-scale experiments on withering have been performed, some of which will be followed up by further experiments using the withering machine. It has been found that leaf withered to about 55% and rolled in a Pizey roller ferments much more slowly than leaf withered to 75%. Highly withered leaf requires more rolling than normally withered leaf to develop the same colour and strength, and this extra rolling also improves the briskness. However the effect of this rolling on quality, and the amount of quality in the highly withered relative to the normally withered tea, are matters of disagreement between the two Tasters whose opinions were sought. In a similar type of experiment carried out in 1950 there was an indication that the best liquoring tea could be made by withering high and rolling hard. The conflicting nature of this year's results makes it impossible to draw any definite conclusions, and further investigations is necessary.

The main experiment on withering was designed to show the separate effects of (1) loss of moisture and (2) time interval between plucking and

manufacture on liquor characters. A full report on this experiment has already been issued, and it was also the subject of a talk by the Biochemist at the Annual Conference.

The following treatments were given :—

1. No wither ; leaf manufactured immediately after plucking.
2. A quick, artificial wither lasting approximately $2\frac{1}{2}$ hours.
3. Storage in moist conditions for the same length of time as normal withering ; very little loss of moisture, leaf appearing quite fresh at the end of storage.
4. A normal wither.

After these treatments the leaf was cut in a Legg tobacco cutter kindly loaned by Messrs. Duncan Brothers, and then rolled in a modified roller. A second portion of the normally withered leaf was rolled conventionally, without cutting, to serve as a standard. The tobacco cutter was used owing to the impossibility of making good tea in the conventional way from leaf which has had no physical wither. The complete experiment, producing five different teas, was performed eleven times, and samples were sent to a total of twelve Tasters.

The main conclusion which could be drawn from the combined tasting reports was that colour and strength are improved as a result of the normal withering process, and that this improvement is due to the time interval elapsing between plucking and manufacture rather than to the loss of moisture. Tasters were unanimous that the tea made from leaf which was stored in moist conditions had more strength than that made from fresh, unwithered leaf. The suggestion in the Annual Report for 1950 that the best strength would be found in an unwithered tea has not, therefore, been borne out.

Considerable difference of opinion existed as to the presence or absence of "brassiness" in any of the samples, and also to the order of preference of the five teas in respect of quality and briskness. "Brassiness" is a term which has come to be associated with unwithered teas, and is responsible for much of the prejudice against them. In the present experiment some Tasters stated positively that none of the samples tasted brassy ; some condemned the unwithered tea as brassy on every occasion ; most found it brassy on some occasions and not on others. (Compare the opinions expressed in a similar small scale experiment reported in the Annual Report for 1950). The term brassiness was also applied freely to the quickly withered tea and sometimes to that made from leaf stored in moist conditions. The majority opinion considered that the unwithered and quickly withered teas had a similar character, not necessarily brassy, which distinguished them from the other three teas. This character, accordingly, would appear to be lost during the period of storage before manufacture, along with the development of colour and strength.

Opinions on quality and briskness were so at variance that it was not possible to draw any conclusions about their behaviour as a result of the various treatments. One point of considerable interest is that the majority of Tasters

preferred the unwithered tea for quality to either of the normally withered teas. Although the difference in most cases was only slight this contrasts very strongly with last year's small scale experiment mentioned above.

Certain of this year's samples have recently been submitted to Tasters in London who did not take part in the experiment, and considerable surprise was expressed that tea of such merit could be made from unwithered leaf.

The quick artificial wither was achieved in a revolving drum placed in a vigorous current of warm, dry air ducted from the dryer. It was not possible to prevent a certain amount of mechanical damage to the leaf, even with speeds as slow as 4 r. p. m., and at the end of withering local fermentation had started at damaged sites. If this damage could be prevented the liquor would be improved. The overall opinion was that this tea had the worst liquor, although one Taster, in striking contrast, considered it to have the best. If quick withering could be successfully and economically carried out in N. E. India it might prove a useful process to supplement natural withering during peak periods, when the amount of withering space is insufficient for the quantity of leaf. In Ceylon quick withering has proved a success on a commercial scale.

It is not intended to base any practical recommendations on this year's experiment, which investigated one type of leaf only and as near as possible one set of conditions. This limitation, together with the unexpected differences of opinion among Tasters, make it necessary to obtain more information on the subject.

D. J. Wood.
Biochemist.

PLANT PATHOLOGICAL DEPARTMENT.

Staff.

Mr. E. Hainsworth, the Pathologist, resigned his post and left Tocklai on 17th May, 1951, while the Entomologist was on leave in the U. K., and Mr. K. C. Sarmah acted for the Pathologist. The Entomologist on his return from leave on 14th October, 1951, took over charge of the Pathology Branch.

The Entomologist, during his leave worked in the British Natural History Museum, London and visited several Agricultural Institutions in the U. K. He also attended the International Congress of Entomology held at Amsterdam.

BACTERIOLOGY.

Weekly bacteriological tests of the Tocklai water supply were carried out throughout the year with the following results:—

Mean numbers of lactose fermenting bacteria per cc of water.

Month.	Untreated.	Treated.
January	11	1
February	7	0
March	5	1
April	6	0
May	7	1
June	2	0
July	6	0
August	4	0
September	2	0
October	3	0
November	2	0
December	1	0

The figures show that the water sterilising plant functioned satisfactorily during the year.

Water samples from 7 gardens were received and tested for bacterial contamination and treatments were suggested where necessary.

MYCOLOGY.

Red rust.

The figures obtained from the spraying experiments, on the control of Red rust on hedge planted young tea, at Kotalgurie Tea Estate and Borbhetta, during one season only, showed no significant difference between the treatments.

Some experiments were undertaken at the special request of the Manager of Kotalgurie Tea Estate to investigate the possibility of eradication of Red rust from severely affected young tea, by adjustment of pruning dates and modification of pruning methods.

Assessment of Red rust infection, made at the height of its fruiting period (May), showed no difference between the treatments.

The experiments were discontinued.

Spectrographic analysis.

This work is still in progress in another Research Station in India. The results are expected to be available some time in 1952.

Black rot (*Corticium* **spp.**).

Experiment No. 1.

A series of experiments was started at Meleng Tea Estate, to determine whether there is a critical stage in the life-cycle of the Black rot fungus at which it is possible to kill it by spraying with a standard copper fungicide.

The observations on the growth of the disease from its resting stage showed that the fungus made no noticeable growth before the 9th of April and so far the year 1951 was concerned the crucial stage of development appeared to be from early April to end of May.

From these experiments it appears that appreciable reduction in the incidence of the disease was effected by two rounds of spraying at fortnightly intervals, between 9-4-51 and 4-6-51 (i.e. early April and end of May) and that this prophylactic treatment was almost equal in its effect as spraying in the growing season.

This effect was corroborated by the results of similar treatments applied at the same period in one garden in Upper Assam and another garden in the Dooars.

The experiment will be continued with a number of Copper fungicides, at two concentrations, in 1952.

Experiment No. 2.

All the fungicides used in the past experiments on Winter spraying for the control of Black rot failed to produce any appreciable effect. In the cold season of 1951, an experiment was undertaken at Katonibari Tea Estate in association with the Scientific Officer of the Jorehaut Tea Co., Ltd., to evaluate a further series of fungicides used as winter sprays on tea bushes known to be badly affected by Black rot (*Corticium invisum*).

The materials used were —

(1) Shalimar Winter Wash.

(2) Standard Vacuum—Sova Spray.

(3) B. O. C. Oil No 1.

(4) B. O. C. Oil No. 2.

(5) Imperial Chemical Industries 'Capsine'.

(6) Perenox 0.25%.

(7) Perenox 0.25% plus Sandovit.

(8) Control.

Each of these was applied on 5 groups of bushes with 10 bushes in each group i. e. 50 bushes.

Final observations were made (on 10th of August) at the time when the effect of the disease was most noticeable. The results are as follows –

Fungicide	Date of application	Percentage of bushes affected on 10.8.51
1. Shalimar Winter Wash (5% emulsion)	27.2.51	46
2. 'Sova Spray' (Neat)	27.2.51	36
3. B. O. C. Oil No. 1 (Neat)	27.2.51	62
4. B. O. C. Oil No. 2 (Neat)	27.2.51	42
5. 'Capsine' 5%	2.3.51	64
6. Perenox 0.25%	27.4.51	56
7. Perenox 0.25% plus Sandovit	27.4.51	14
8. Control	—	64

12 ozs Sandovit per 100 gallons of spray fluid

From the above figures it is evident that even one round of spraying with Perenox 0.25% plus Sandovit when applied in late April (during the critical period of development of the fungus) was more effective than any of the winter sprays. The figures show the remarkable increase in efficiency of perenox when used with the wetting agent Sandovit.

Experiment No. 3.

Based on the observations mentioned in Experiment No. 1, six Copper fungicides, each at four concentrations (0.25%, 0.5%, 0.75% and 1.0%), were applied on Black rot infected branches in the third week of April. Only one application was made. An assessment on the development of Black rot was made after a fortnight.

The differences between 0·25% and the higher concentrations do not appear to be sufficient to warrant the extra cost.

The above treatments were repeated however at two concentrations in another experiment, after a month. The growth of the fungus by this time extended to the leaves and therefore examination in the field gave a higher figure. The affected bushes were sprayed for the second time after a fortnight of the first application.

It would appear from the results that two applications at the crucial period at an interval of about two weeks with 0.25% solution may be more beneficial than one application with a higher concentration. It is our experience that a thorough and complete covering of the affected parts with a spray fluid can hardly be ensured with one application and the fungus starts growth again from the places which escape contact with the spray.

Blister blight.

Blister blight attacks persisted, from its autumnal outbreaks, through the winter period on early pruned tea, nurseries. sample pruning bushes etc., especially where they happened to be under heavy shade or alongside jungles, in almost

all districts. The disease appeared to get a hold on tea which had been manured late in the previous season. The attack was favoured by the damp, warm weather which prevailed during November-December 1950. Fortunately the long drought saved the tea from being seriously damaged. Frequent visits were made to some local gardens to study the different factors influencing the development of the disease. An early spring outbreak was anticipated as a result of our observations and a circular was issued suggesting immediate measures of control in case such an attack developed.

The long spring drought was the single factor which arrested the epidemic. Operations against Blister blight were considerably assisted by the prompt information which came from estates Managers giving news of outbreaks of Blister blight on their gardens.

Incidence of the disease was reported from 15 estates, mostly in Upper Assam in April and 11 estates in May. It however cleared up by the end of May.

Root disease control (Experiment as per 3rd Quarterly Report, 1950).

Tea bushes, previous'y killed by injecting Atlas Tree Killer, and then inoculated on their roots with 4 different fungi (known to be parasitic on tea) were uprooted after 6 and 10 months from the date of inoculation. The roots were examined for the spread of the diseases. The results were as follows :—

Spread of the fungi in the Root from the point of inoculation in cms. (Average of 6 bushes)

	After 6 months				After 10 months.			
	Up		Down		Up		Down	
	Living	Dead	Living	Dead	Living	Dead	Living	Dead *
Charcoal stump rot *(Ustulina zonata)*	3.0	4.0	3.0	17.0	2.6	6.8	4.8	13.8
Red root rot *(Poria hypolateritia)*	0.6	5.7	4.3	17.1	2.3	4.6	3.0	13.0
Brown root rot *(Fomes lamaoensis)*	0.8	7.3	3.0	14.5	2.1	6.0	3.5	7.5
Aglaospora sp.	3.0	6.0	6.0	19.0	3.1	8.0	6.0	11.3

* The root ends in most cases were eaten away by termites.

The figures show that the spread of the above mentioned fungi is more rapid in the roots of bushes killed by poisioning than in those of living bushes

It should be noted that this effect was observed only on tea bushes, which were inoculated. Whether the same effect will be produced on shade and other trees is a matter which requires further investigation.

In another experiment bushes badly affected by Charcoal stump rot were injected with a lethal dose of Atlas Tree Killer. Examination of treated bushes at monthly intervals showed that in every case the fungus was alive in the wood 1" away radially from the hole into which the poison was injected. The poison has practically no effect on the fungus.

ENTOMOLOGY.

Pink mite.

Occasional incidence of Pink mite was noticed at Tocklai for the last two years but it never took a serious turn and the mites almost disappeared with the advent of rains. This year, however, it appeared in severe form in one of the neighbouring gardens and caused considerable damage to tea.

This mite attacks both the upper and the under surfaces of the leaves, mostly on or near the mid ribs and veins, but it appears to be more active on the under surface. The young leaves are preferred. It is also quite common on tender shoots. As a result of damage, the veins assume reddish brown colour and the leaf surface turns brown with pink tinge.

During cold weather, a few mites may be found on the old leaves but as soon as the bush starts flushing, they migrate to the young leaves.

Lime sulphur spray (1 in 40 parts of water) was applied for the control of the pest. Though thorough coverage of the undersurface was not possible for want of efficient spraying equipment on the garden, lime sulphur gave almost complete control of the pest. This was achieved mainly due to the fact that lime sulphur not only acted as a contact poison but also as a fumigant and those mites which escaped direct hit with the fluid were also killed, including the young ones hatching out from the eggs subsequently.

The adult mite is exceedingly small, pear shaped, pinkish in colour and cannot be seen without the aid of a lens. The body is wide anteriorly, progressively narrowed posteriorly and has numerous transverse striations. It has two pairs of legs which are directed forwards.

The eggs are minute, globular, and almost transparent. Incubation period is about 5 days in the month of June.

Further studies on this pest are in progress.

Tea Seed Bug.

Various insecticides have been tried against Tea Seed Bug but none has proved to be effective In the laboratory trials, however, Pyrocolloid gave

100% knock down and the bugs dropped on the ground from the branches shortly after spraying. They however, recovered after a day or two.

Until now, collection by various methods has been recommended for the control of the pest, but this procedure is not very efficient since many of the bugs at the top branches are not within easy reach.

Further trials in the laboratory as well as in the field with Pyrocolloid are needed and if found suitable, Pyrocolloid may be applied by means of power sprayer, to knock the bugs down, when they can easily be hand collected from the ground which should be kept clean before spraying.

Mound termites.

Cyanogas, af umigant consisting of Calcium Cyanide, was tried out against termites in mounds. It gave 100% control of termites in the mounds which were treated by means of foot pump, but 50% of those treated by pouring the fumigant into the holes, recorded many living termites.

Cricket.

In small trials at Borbhetta, Cyanogas gave very satisfactory control of Crickets in the burrows. About a tea-spoonful of this fumigant was applied into each hole and then the mouth was plugged with soil immediately after application.

The burrows were excavated on the following day, and the results are given below.

12 holes, with 2 crickets in each hole	...	24	dead crickets.
2 holes, with 1 cricket in each hole	...	2	„ „
3 holes, with no crickets ...	...	0	„ „
3 holes, where crickets escaped through fresh openings	...	0	„ „

The fumigant is more effective than the insecticides used previously for the control of Crickets. The method of application is also simpler than the others described in Tea Encyclopaedia Serial No. 78, filed under J. 3.

It may however be mentioned here that the only defect with the product is that it deteriorates, if it is subjected to long exposure.

Plants lice.

A. odoratissima. seedlings are badly attacked by Plant lice and it has become a problem to raise the plants in the nurseries in Darrang and the Dooars. These plant lice attack the leaves, petioles and the tender stem of the seedlings, and as a result of damage, the growth of the plants is checked, internodes become shortened and the top presents a characteristic appearance of "Cabbage growth." This also encourages the production of small side branches which are similarly affected.

Curative treatments with various insecticides have not proved to be fully effective, as the Plant lice remain protected inside the "cabbage growth." If,

however, most of the leaves at the top (Cabbage growth) are removed and then the seedlings are sprayed with any standard lime sulphur at 1 in 45 parts of water or lime sulphur plus DDT (1 lb. of DDT to 50 gallons of lime sulphur solution) the pest can be easily controlled. The badly damaged plants however after recovery from the attack do not seem to grow well when planted out in the field and prophylactic treatment is the only answer to this problem.

An experiment was conducted in Chuapara Tea Estate in co-operation with the Manager, with the following treatments against these Plant lice.

1. Gammexane D.025 as a dust.
2. Lime sulphur plus DDT as a spray (1 lb. DDT 50% to 50 gallons of lime sulphur solution made up at 1 part lime sulphur to 45 parts of water).
3. DDT 50% Wettable Powder as a spray (1 lb. to 50 gallons of water).
4. Untreated.

From the results of observations it appears that both lime sulphur plus DDT, and Gammexane gave very satisfactory results as prophylactic control against Plant lice, but DDT alone only reduced the intensity of damage.

Another experiment, where prophylactic treatments with (1) Lime sulphur (2) Gammexane (3) Tobacco decoction and (4) Blitox* followed by Whiz were carried out, the results were not encouraging at all, though the lime sulphur treated plot was the least attacked.

Red Spider.

Wetting Agents — Laboratory tests conducted to estimate the increase in efficiency of Spersul, a form of water dispersible sulphur, indicate that the addition of wetting agents gives earlier kill of active forms of Red spider. Spersul has little effect on the quiescents and eggs of Red spider, and addition of wetting agents makes practically no difference.

* Blitox is a copper fungicide which has no insecticidal value.

	Total active forms	Killed in				Total quiescents	Percent killed	Total eggs	Percent unhatched
		6 hrs	24 hrs	48 hrs.	96 hrs.				
Spersul 1 lb. in 10 gallons of water	285	12.2%	62.1%	93%	100.%	22	4.5%	341	1.8%
Spersul 1 lb. plus Spreadite 1 oz., in 10 gallons of water	204	33.3%	85%	99%	100.%	56	5.4%	160	0.0%
Spersul 1 lb. plus Spreadite 2 ozs. in 10 gallons of water	273	97%	100%	—	—	26	7.7%	350	2.3%
Spersul 1 lb. plus Sandovit 1¼ ozs, in 10 gallons of water	193	97.4%	100%	—	—	25	8.0%	370	4.2%
Spersul 1 lb. plus Sandovit 2½ ozs, in 10 gallons of water	165	98.2%	100%	—	—	10	10.0%	49	4.1%

Acaricides.

About 20 different acaricides at various concentrations were tested against Red spider in the laboratory ; some of them proved satisfactory but require further trials for confirmation.

G. 22914, an acaricide developed by Messrs Geigy Insecticides Ltd., Basle, was tested against Red spider in the laboratory. At a concentration of 1 lb. to 10 gallons of water, it killed all active forms, but had no action on quiescents and eggs. Fumigating effect of G. 22914 appears to be moderate, but does not persist long enough to kill all the larvae hatching out at later dates.

Incorporation of dyes into spray fluids.

The question of incorporation of dyes into insecticides and fungicides in order to find out the efficiency of spraying, particularly when sprayed by means of a low volume sprayer, was investigated.

Only Red and yellow dyes were used with Perenox and Coppesan in the trials.

Red dye at 0.5 per cent concentration with Perenox and at 0.25 per cent with Coppesan gave distinct visibility immediately after spraying and also later when dry.

Yellow dye did not prove to be satisfactory for the purpose.

The cost of dye stuff at 0.5% appears to be about three times that of Perenox.

Advisory.

420 specimens of fungus diseases and insect pests were examined and reported on.

879 memoranda were issued in connection with diseases and pests.

Publication.

The following Tea Encyclopaedia Serials and Circulars were published during the year.

1. "The Blister blight epidemic" — Circular.
2. "Blister blight in the Plains Estates" — Circular.
3. Tea Encyclopaedia Serial No. 86, filed under 1.4.
4. Tea Encyclopaedia Serial No. 87, filed under 1.4.
5. Tea Encyclopaedia Serial No. 8/1, filed under 1.3.

Touring.

The Pathologist visited 17 gardens during the period January — May and the Actg. Pathologist visited 12 gardens during the remaining period. The Entomologist visited one garden in Darrang and six gardens in the Dooars, in connection with the control of Plant lice attacking *A. odoratissima* seedlings.

K. C. Sarmah.
Actg. Mycologist.

G. M Das.
Entomologist.

PHYSICO-CHEMICAL BRANCH.

1. Analytical and Advisory work : During the year a large number of soil and other samples were received for analysis and advice. The following number were actually reported on during the year.

Soil	samples ...	811
Manure	„ ...	102
Water	„ ...	15
Others	„ ...	12

The Department issued 262 technical reports during the year in connection with specific problems of tea gardens. In addition, a large number of letters of technical nature were written to gardens, commercial firms and Government Departments.

2. Touring : During the year, the Physical Chemist paid visits to 22 gardens in the Jorhat, Dhunseri, Doom Dooma, Dibrugarh, Panitola and Nowgong Circles with reference to specific problems concerning the department.

3. Publications : During the year, five Tea Encyclopaedia Serials were either revised or completely rewritten.

4. Fertiliser position : During the last 3 years a large number of fertiliser mixture samples have been tested with a view to check on their quality and purity. As a result of this work certain discrepancies and irregularities were brought to light. One obvious source of trouble was adulteration of fertilisers en route to gardens. The position was reviewed and brought to the notice of the Indian Tea Association. Necessary action is now being taken to ensure that the mixtures supplied to gardens are of the required quality and purity and that there is no tempering en route.

Although this work has been of use in bringing to light the unsatisfactory position of fertiliser distribution, purely routine work of this nature does interfere with the research programme and it has been decided that routine testing of fertiliser samples for gardens will not be undertaken by Tocklai, in future.

5. Study of soil aeration : It is proposed to carry out a detailed investigation on the composition of the soil air under varying conditions of soil types, drainage status etc. with a view to check on soil aeration under these different conditions. Preliminary work has been started at Tocklai on CO_2 determination at different levels and the manner in which the changes occur during the day and throughout the year, in tea areas and in fallow land.

6. Petrological analysis : A study of the soil minerals present in the soil types of North East India has been commenced.

7. Climatology : The first quarter of the year was abnormally dry and the total rainfall during the cold weather 1950-51 was less than $1\frac{1}{2}$". In general this was true for all of North East India and as a result semi-drought conditions prevailed in most areas during the first quarter. In places like Golaghat and Nowgong the effect was more prolonged with detrimental effects on the tea, the gardens being anything up to 40% behind crop, on the previous year, until the end of June.

The total annual rainfall at Tocklai was well below normal : monthly rainfall being above normal only in 2 months—April and October. The onset of the monsoon this year was late.

Average temperatures as well as hours of sunshine were higher during the first and the third quarters.

The prolonged drought conditions during the first quarter had one good effect. Conditions in the last quarter of 1950 had been especially favourable for Blister blight and had it not been for the drought conditions following it, the disease might have assumed serious proportions.

Full results for the year for Tocklai are given below—

STATEMENT A.

1951	Rainfall (inches)	Wet days	Temp. Maximum monthly average °F	Temp. Minimum monthly average °F	Hours sunshine daily average	Rainfall average 30 years	
						Inches	No. of wet days
January	0.21	2	72.82	48.19	6.89	0.90	5
February	0.09	1	76.99	52.81	7.26	1.37	8
March	3.17	12	82.15	60.23	6.47	3.24	11
April	11.59	20	80.55	63.52	5.51	7.83	17
May	6.61	15	86.01	70.50	4.91	10.44	20
June	11.63	21	87.28	74.74	4.00	13.04	23
July	14.50	23	88.77	75.66	6.17	14.98	24
August	9.41	21	90.15	76.46	6.64	13.15	23
September	3.27	9	89.33	74.46	7.85	10.70	20
October	8.89	14	84.07	70.05	5.49	4.39	11
November	1.55	8	77.88	59.59	6.36	1.09	4
December	1.04	3	74.25	50.99	6.25	0.42	3
Total	71.96	149				81.55	169
Average			82.52	64.77	6.15		

STATEMENT B.

(i) Relative Humidity, monthly averages
1951

	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Octr.	Nov.	Dec.
8 a. m.	94	89	85	83	85	89	88	91	90	93	93	95
12 noon	65	55	53	69	71	80	78	77	75	78	73	67
2 p m.	57	49	48	61	67	76	73	74	70	71	68	59

(ii) Vapour Tension in inches of mercury
monthly averages
1951

	Jan.	Feb.	Mar.	Apr	May	June	July	Aug	Sept	Octr.	Nov.	Dec.
8 a. m.	.377	.432	.526	.576	.768	.863	.888	.946	.890	.788	.569	.418
12 noon	.442	.431	.499	.585	.792	.891	.916	.966	.893	.804	.610	.483
2 p. m.	.431	.425	.479	.578	.772	909	.904	.985	.892	.786	.607	.476

STATEMENT C.

Soil Temperatures F and Soil Moisture.

1951	Soil Temperature at 1 ft.				Soil Temperature at 3 ft.				Soil moisture % (top 9")
	Fallow		Grass		Fallow		Grass		
	8 a.m.	2 p.m.	8 a.m.	2 p.m.	8 a.m.	2 p.m.	8 a.m.	2 p.m.	
January	65.49	65.35	65.43	65.41	69.37	69.35	67.89	67.89	12.49
February	67.66	67.79	66.93	66.97	69.30	69.44	68.37	68.59	8.65
March	72.93	72.77	72.07	71.95	72.55	72.60	72.56	72.61	7.11
April	74.94	74.55	75.21	74.76	74.71	74.73	75.33	75.21	15.15
May	79.91	80.29	80.41	80.43	77.47	77.59	79.32	79.34	16 55
June	83.74	83.90	84.29	84.23	80.59	80.61	83.28	83.29	18.06
July	85.25	85.37	85.65	85.60	82.69	82.71	84.90	84.97	18.05
August	86.92	86.83	87.32	86.94	83.80	83.77	86.55	86.47	18.28
September	86.04	86.21	86.30	86.21	84.89	85.14	86.15	86.22	17.32
October	82.05	81.78	82.39	82.09	82.64	82.67	83.10	83.09	17.68
November	75.32	75.26	76.08	75.73	78.44	78.34	77.85	77.60	15.22
December	67.48	67.63	68.56	68.45	72.45	72.48	71.00	71.99	13.55

8. Seismographs : During the year the instrument belonging to the Indian Meteorological Department, Seismology Section, continued to record satisfactorily.

N. G. Gokhale.
Physical Chemist.

ADVISORY BRANCH ASSAM VALLEY & NORTH BANK.

1. Touring :

Prior to his departure on Home Leave, the Advisory Officer toured in the Jorhat, North Lakhimpur, Panitola, Moran and Borsola Circles. Since his return to Tocklai, he has visited gardens in the Jorhat and Nazira Circles.

2. Meetings :

The Advisory Officer attended the Annual General Meeting of the Surma Valley Branch, Indian Tea Association, and addressed the Meeting on technical aspects of the work of the Cachar Plantation Committee, of which he was a member. While in the Surma Valley he visited two gardens. He also attended the Third Annual General Meeting of the Pakistan Tea Association representing the Chief Scientific Officer, and addressed the Meeting. A visit was also paid to Shamshernugger Tea Estate, while in Pakistan.

3. Leave :

The Advisory Officer went on leave to the United Kingdom on 15th March, 1951 and returned to Tocklai on 12th October, 1951. During his absence Mr. J. W. Crichton, Advisory Officer designate for the Dooars officiated for him. Mr. Crichton visited a number of gardens on which the Advisory Branch is running experiments, in connection with Agrotype survey.

4. Resignation :

Mr. J. W. Crichton resigned his post as Advisory Officer designate for the Dooars, due to circumstances beyond his control. He left Tocklai for the United Kingdom on 28th October, 1951.

5. Memoranda :

Over 300 memoranda were issued during the year in answer to letters or as result of visits to gardens.

6. Publications :

A Technical Report was prepared by the Advisory Officer in his capacity as representative of the Scientific Department on the Cachar Plantation Enquiry Committee. This report entitled "A Report on Tea Cultivation in Cachar with recommendations as to methods of improvement", was printed and published during the first quarter of the year, as an Indian Tea Association Bulletin, with the permission of the Enquiry Committee.

7. Lectures :

The Advisory Officer delivered lectures on "Tea Nurseries", "Planting Out", and "Pruning of Young Tea", to the Agricultural College Degree Course students, at the Assam Agricultural College, Jorhat.

8. Visits in the United Kingdom :

While on leave, the Advisory Officer, Assam, visited :

British Industries Fair. Olympia and Earls Court ;

British Industries Fair. Castle Bromwich, Birmingham ;

Messrs. Plant Protection.	Imperial Chemical Industries Research Station Fernhurst, including attendance at "Machinery Day".
Messrs. Davidsons,	Sirocco Works, Belfast ;
Messrs. Marshall & Co.,	Works, Gainsborough.
Messrs. Drake & Fletcher.	manufacturers Spraying Machinery, Maidstone.

9. Spraying Machinery :

The greatest need of the Tea Industry at the present time in the field of spraying is an efficient method of application of sprays. As result of visits made while on leave in the United Kingdom, it appears that the most satisfactory method at present available for the application of insecticides and fungicides to tea, is the central charge pump, battery pneumatic knapsack sprayer system. Briefly, this system employs knapsack sprayers which are air-pressure retaining, and into which the liquid is pumped by means of a central charge pump which may be either hand, or machine operated. One hand operated central charge pump can easily maintain 12 knapsack type sprayers in the field; a machine operated central charge pump could maintain many more.

Three such systems were seen : these are —

(a) Four Oaks system : Agents in India Messrs. James Warren & Co.

(b) Cooper Pegler Favori system : Agents in India Messrs. McLeods.

(c) Drake & Fletcher Mistifier system : Agents in India Messrs. Jardine Hendersons.

All these firms have offered equipment to Tocklai for trial and demonstration purposes in 1952.

Such machinery, combined with low volume spray nozzles, will reduce the gallonage and spraying time per acre very considerably, while affording improved cover.

Experience at Tocklai suggests that liquid insecticide and fungicide spraying is much more satisfactory than dusting. A new type of spraying machine which is considered promising, is being produced by such firms as Messrs. Clean Crops Limited of London. A machine of this type called the "Micron Sprayer" was demonstrated at Fernhurst. The "Micron" is a mist blower whose effective range is said to be 60–80 yards, and is mounted on wheels and provided with a tow-bar for hitching to a tractor. The inventor claims that a very small quanity of liquid can be evenly distributed over an acre in the course of a few minutes. A "Micron" machine is at present on its way out to Tocklai for trial and test, and is expected to arrive in June 1952.

10. Incorporation of colouring matter into Insecticides and Fungicides.

The possibility of incorporation of colouring matter into insecticides and fungicides in order to make it easy to check that spraying has been satisfactorily

carried out, was investigated in conjunction with the Pathological Department. Red and yellow dyes were tested. The yellow dye was found to be unsatisfactory. The red dye was that used at the "Holi" festival, and is readily available locally. The suggestion as to the use of this particular dye stuff came from Mr. McNeill, Scientific Officer of the Jokai (Assam) Tea Company, Ltd.

With Perenox, the red dye at a concentration of 0.5% was clearly visible both immediately after spraying, and also later when dry. With Coppesan the same effect was obtained using the dye at only 0.25%.

It was estimated that when using Perenox as a Fungicide the cost of dye stuff per acre would be not less than Rs. 8/-. The cost of dye stuff therefore, would be approximately three times the cost Perenox for the same area. This being so, it would probably be more satisfactory to use three rounds of Perenox to ensure satisfactory coverage rather than one round of Perenox plus dye.

It has been found that a 0.25% solution of this magenta dye in water produces satisfactory spotting on cards and this technique will be utilised in testing such spraying machinery as the "Micron Sprayer".

11. Crotalaria Seeds :

An experiment was carried out April-June to compare the germination capacity of seed from unlopped *Crotalaria anagyroides* with that of seed from plants which were late lopped. This experiment was also designed to discover whether plants developing from the latter seed would be stunted in growth. Results of these trials were inconclusive, but it may be stated that the main consideration in respect of lopping versus not lopping is whether in the former case, sufficient time is left for the seed to mature.

12. Red Rust :

No significant difference in Red Rust effect was observed between the plots pruned at varying times and in varying manners at Kotalgoorie Tea Estate (vide Annual Report for 1950). This experiment was therefore terminated. vide Annual Report Pathological Branch, 1951 page 28.

13. Manuring on Bheel Soils :

This experiment is being carried out at Bhubandhar Tea Estate with the object of discovering methods of increasing yields from tea on bheel soils, on which nitrogen alone has been shown in the past to have no effect.

Treatments are —

P_2K_3	P_2O_5 60 lbs : K_2O 90 lbs: per acre.
Cattle manure —	200 mds. per acre.
Calcium sulphate —	1 oz. per bush.

Preliminary yields were taken in 1950. In the first year of the experiment the gain from P_2K_3 over calcium sulphate was 1.03 mds. which just misses significance at the 5% level.

Treatments are being continued in the current year, and results will be compared with those obtained by the Scientific Officer, Jokai Company in an experiment on manuring bheel soils at Sephinjuribheel Tea Estate.

14. **Sulphate of ammonia and Oilcake :**

This experiment at Jamirah Tea Estate is now in its fourth year

Treatments are —

Check
80 lbs. N as sulphate of ammonia
80 lbs. N as oilcake.

Again in 1951, as in 1949 and 1950 the yields from both 80 lbs. N as sulphate of ammonia, and 80 lbs. N as oilcake were significantly better than from the check. (P= 0.05).

The yield from 80 lbs. N as sulphate of ammonia was greater by nearly 2 mds. than from 80 lbs. N as oilcake, but this figure is not significant at the 5% level. In only one year since the experiment began has this difference been significant ; this was in 1949 when it amounted to 3 mds.

The efficiency of oilcake on this sandy soil, and with a heavily shaded Manipuri tea is interesting, and the experiment will be continued, for at least one more year.

14. **Organic versus Inorganic Manures :**

This experiment was started at Halem Tea Estate in 1933.

Treatments are —

Cattle manure	— 200 mds. per acre.
Inorganic fertilisers	— 40 lbs. N as sulphate of ammonia
	— 20 lbs. P_2O_5 as superphosphate
	— 20 lbs. K_2O as muriate of potash.

In 1951 the cattle manure analysed at 0.76% N on wet weight, so that 200 mds. cattle manure per acre was equivalent to 121.5 lbs. N per acre.

Yields from these treatments were respectively cattle manure 21.2 mds. and inorganic fertiliser 22.62 mds. per acre, both are significant over the check, 17.99 mds, at the 5% level. As in 1950 the increase in yield from inorganic fertiliser is significantly greater than from cattle manure.

The cost of inorganic fertiliser was approximately Rs. 68/- per acre of which Rs 4/- was cost of application. The cost of cattle manure was about half as much per acre (Rs. 32/-) of which Rs. 18/- was cost of application.

15. **Shade — Nitrogen and Plucking :**

Experiments are in progress on one garden in the Jorhat circle and three in the Dooars

Treatments are —

Two levels of nitrogen 40 lbs. and 120 lbs. per acre.
Two tipping heights 6" and 9".
Shade and No shade.

(a) Hunwal Tea Estate.

This experiment is now in its fifth year. The shade is very light and the tea, Betjan., Increase in nitrogen from 40 to 120 lbs. per acre gave an average increase in yield of 6.5 mds. per acre The increase from unshaded plots was 7.7 mds. and from the shaded plots 5.2 mds.

Shade gave an average increase of 4.2 mds. the increase from plots with the lower rate of nitrogen was 5.4 mds. and from those with the higher rate 2.9 mds. All figures are significant at the 5% level.

The higher tipping horizon has had no significant effect on yield from either the shaded or unshaded plots, or with either the higher or lower level of nitrogen application.

(b) Moortee Tea Estate.

In the fourth year an increased application of fertiliser from 40 to 120 lbs. N per acre gave an increased yield of 2.22 mds. under shade, and depressed yield by 1.28 md. in the full sun. With the higher rate of nitrogen the gain from shade was 1.76 mds. with the lower there was a loss of 1.74 mds. The figure 2.22 only, closely approaches significance at the 5% level.

The longer plucking measure gave an increased yield of about 1 md. per acre from both shaded and unshaded plots. These figures are not significant at the 5% level. The longer measure gave an increase in yield of 2 mds. per acre with the higher level of nitrogen. This figure closely approaches significance

The results vary considerably from those obtained in 1950.

(c) Baradighi Tea Estate.

In the fourth year of the experiment an increase in nitrogen application from 40 to 120 lbs. per acre gave no increase in yield either under shade or in the full sun.

As in previous years shade depressed crop to a highly significant extent.

The longer tipping measure had no effect on yield at either level of nitrogen application. In the full sun it depressed yield to a significant extent 1.12 mds., in the shade there was an increase of 0.81 mds. which just misses significance at the 5% level.

(d) Rydak Tea Estate.

As in 1950, the higher level of nitrogen gave a significant increase in yield of 1.75 mds. from the unshaded plots, and no gain under shade.

As in the previous year the higher tipping horizon reduced yield. This reduction was only significant however, at the 5% level in the case of plots at the lower rate of nitrogen application (1.03 mds.).

16. N. P. K. Experiments.

A series of experiments was started in 1937 to detect any detrimental effect which might arise over a period of years from the application of an unbalanced fertiliser (i. e. supplying nitrogen only) to tea.

These experiments were begun in 1936-37 ; all manuring was stopped from 1944 to 1947 due to war time shortages. In 1948, as no superphosphate was available, only N and K were applied. In 1949 full manuring was begun again for the first time since 1943, at the following rates—

N 120 — P 40 — K 40.

Results obtained in 1951 are given below—

(a) Bindukuri Tea Estate.

In both experiments on this garden all treatments gave yields significantly better than from the check plots with the exception of the increase in yield from NK which in each instance just misses significance at the 5% level. In both cases nitrogen alone gave significant increases in yield, and in both the yield from NK was less than from nitrogen alone, though these differences are not significant at the 5% level ; the lower yield from NK in Expt. X71 approaches significance. Yields from NP and NPK do not differ significantly from yields from nitrogen alone.

(b) Moortee Tea Estate.

No treatment (including nitrogen alone) gave a yield significantly better than that from plots which received no fertiliser whatsoever

(c) Rydak Tea Estate.

All treatments gave yields significantly better than from the check plots. Yields from NP, NK and NPK were no better than from nitrogen alone.

17. Shade and Manuring.

This series of experiments on eight gardens on the North Bank is now in its fourth year.

Treatments are—

Check
60 lbs. N as sulphate of ammonia
120 lbs. N as sulphate of ammonia
200 lbs. N as oilcake.

It is proposed to obtain the yield figures for the fifth year and then to examine the whole series in relationship to Agrotype index and intensity of light under the shade. Until these latter factors are known it is difficult to comment upon results obtained so far.

This survey should give a most useful picture of the reaction of different kinds of tea to organic and inorganic nitrogen under varying light intensity.

P. M. Glover,
Advisory Officer : A. V. & N. B.

ADVISORY BRANCH : DARJEELING & TERAI.

1. General :

Consequent to the temporary transfer of the Advisory Officer, Darjeeling & Terai to Tocklai to officiate for the Chief Scientific Officer on 30th May, 1951 followed in October by his proceeding on leave ex : India, the office of The Advisory Officer in Kurseong was closed down on 30th May, 1951. As far as was possible in the circumstances current Advisory work was undertaken from Tocklai by Branches concerned.

2. Touring :

Visits were made to Estates in the Darjeeling & Terai areas as also several short tours to the Dooars on questions of a specific nature.

The Advisory Officer visited Tocklai in February during the period of the General Courses. In May the Advisory Officer visited Ceylon mainly in connection with Exobasidium vexans (Blister Blight) control, but much valuable information was obtained in connection with cultural methods and manufacture under Ceylon practice.

3. Publications :

Memoranda on "Observations on Manuring & Manuring Policy in Darjeeling Hills" & "Anti—Erosion Measures in the Darjeeling District" were issued to local Estates during the year.

While at Tocklai a start was made on publishing a Memorandum on "Wood Supplies in Tea Estates".

4. Lectures :

Talks on Vegetative propagation methods were given in Darjeeling and the Mal District of the Dooars. The Advisory Officer is indebted to the Manager, Ambootia T. E., for providing materials for demonstration purposes at these lectures.

5. Pathological :

(i) **Drought** — In the period prior to the Advisory Officer proceeding on leave the most important factor affecting crop was the severe drought which occured generally in the whole of the West Bengal tea areas.

In all areas, both young and old tea was severely affected and mortality was considerable.

For the Darjeeling District the drought was particularly serious in view of the fact that existing cultural practice is directed largely to the production of early season crops.

Both in the Hills and in the Plains, the drought showed up weak areas, in the Hills where there was little depth in the soil and in the Plains, particularly in the Mal sands and Red Bank areas.

In the Plains considerable difficulty was experienced in maintaining Tea nurseries, for over large areas, streams—usually relied on for water supplies—dried up early in the year.

(ii) **Metatetranichus bioculatus** (Red Spider).

As might be expected the prolonged drought affected incidence of Red Spider which invaded areas normally relatively free from the pest.

(iii) **Thrip.**

Thrip was relatively quiescent during the drought period, but as soon as rain fell in appreciable quantities and flushing commenced, Thrip immediately became apparent and active.

Trials were initiated in two Estates to test whether spraying with D. D. T. in tea recovering from pruning would be effective in preventing or reducing retardation of growth thus causing delay in the attainment of the tipping level.

At Singell Tea Estate, sprayed plots were compared with unsprayed in respect of incidence of Thrip in plucking shoots.

The spray used was D. D. T. at 0.125% concentration.

Thereafter, at intervals, 40 shoots each were plucked from unsprayed and sprayed plots, and Thrips infesting the plucked shoots extracted by shaking them up in water. The following table shows the counts for the period the trial could be undertaken—

Date of observation	Counts of Thrips on 40 shoots.	
	Sprayed plots	Unsprayed Plots
25-4-51	15	27
3-5-51	17	32
11-5-51	20	40
21-5-51	18	46

It should be noted that during plucking operations it is likely that some insects in the adult and possibly even the so-called prepupal stages may have escaped.

With the kind co-operation of the Manager, Margaret's Hope Tea Estate, a trial was conducted on the Maharanee Division on pruned tea, and provided for comparison between one or two sprayings with D. D. T. combined with tipping levels at 4" and 5".

Treatments accorded were as follows—

(1) Control untreated, tipped at 5"

(2) One round of spraying, tipped at 4"

(3) One round of spraying, tipped at 5"

(4) Two rounds of spraying, tipped at 5"

The first spray was applied on 20-4-51, and the second where applicable on 20-5-51.

Observations by Mr. Prosser, indicated that while the results obtained cannot be considered conclusive, there was evidence that spraying helped the tea to break away earlier than when unsprayed. Reinfestation could not be prevented however. Plucking was undertaken on 17-7-51 and gave the following —

(1)	Control unsprayed	1	seer	of	leaf	per	15.1 tangs
(2)	One round of spraying and Tipping at 4"	1	"	"	"	"	12.4 "
(3)	One round of spraying and Tipping at 5"	1	"	"	"	"	15.0 "
(4)	Two rounds of spraying and Tipping at 5"	1	"	"	"	"	11.1 "

These data cannot be considered as statistically acceptable but are of some interest in indicating trends.

Further detailed trials and observations will be necessary, before any definite conclusions on control can be arrived at.

Trials to determine movement of Thrip in tea were conducted in an Estate at Kurseong, and also in the Kurseong Headquarters. Sticky papers was set up in the tea at different heights from the ground, and examined for Thrip. Attempts were also made to test whether the so-called pupal stage is spent in the soil; by placing on the ground among the tea bushes, glass lantern chimneys covered with sticky paper.

As far as movement of Thrip is concerned, there appeared to be no significant difference between numbers found on the traps at different heights from the ground, though, as might be expected there was a tendency for traps above bush level to catch more insects than those at the lower levels. All the specimens thus caught were adults. This too is what might have been expected, as it is in the adult form only that wings appear, and while the insect is not a strong flier, it can be carried by winds.

Observation on a number of bushes in the Headquarters compound were made daily for a period from March onwards, until the writer left in May. For what it is worth, from what was in effect a laboratory scale trial, D. D. T., when sprayed as a top spray on flushing bushes infested by Thrip, proved reasonably effective in controlling the insect.

(iv) **Spraying & other similar methods of control of pests :**

The visit to Ceylon made in May, referred to in para 2 above, is worthy of further mention.

The impact on the Tea industry there and also in S. India of Exobasidium vexans (Blister Blight), in a most severe form necessitated intensive work on combating it. Considerable experience has been gained on equipment for spraying, dusting and fogging ; and techniques for their use.

The Advisory Officer, Assam Valley & North Bank, has made mention in his Annual Report at para 8 of Low volume pressure retaining Knapsack sprayers.

A short course for Ceylon Planters was held at Kandy which the writer was privileged to attend. At this course much time was devoted to the technique and organisation of spraying with this equipment which it is understood is now universally recommended for use in Ceylon. A considerable amount of work has been done in both dusting and spraying, and both methods are now established practice in Ceylon. In the writer's opinion there is no doubt that the pressure retaining Knapsack sprayer is the best advance in spraying equipment of the one man type hitherto made available, but organisation is required both for maintenance and economy in use.

In the Darjeeling District in view of the high costs involved in water carriage, it is for consideration particularly in the early (dry) part of the season, whether dusting with portable power dusters may not be forced upon the industry in spite of the disadvantages of dusting vis a vis spraying.

Possibly dusting with a D. D. T./Sulphur mixture might constitute an approach to Red Spider and Thrip control, both pests being dealt with in one operation.

The writer visited the Imperial Chemical Industries experimental area at Fernhurst in connection with spraying equipment while on leave in the U. K. He also visited the Agricultural Fat Stock show at Earls' Court where practically every type and make of pest control equipment was on view.

It is hoped that some of the equipment seen will be made available for trial in the near future.

6. Experiments :

The following experiments are in operation :

(1) N. P. K. Manuring—Dooteriah and Kalej Valley,

(2) Pruning cycles — Tumsong, Mim, Nagri.

Unfortunately an area selected at Chamong was badly hit by hail in its initial year and has had to be abandoned.

R. I. Macalpine,
Advisory Officer,
Darjeeling & Terai.